Announcements

- EXAM 3 will be returned at the END of class today!
- Homework for tomorrow…

  (Ch. 20, CQ 3 & 7 (neglect phase constant),
  Probs. 20, 24, & 26)

- Office hours…

  MW 10-11 am

  TR 9-10 am

  F 12-1 pm

- Tutorial Learning Center (TLC) hours:

  MTWR 8-6 pm

  F 8-11 am, 2-5 pm

  Su 1-5 pm

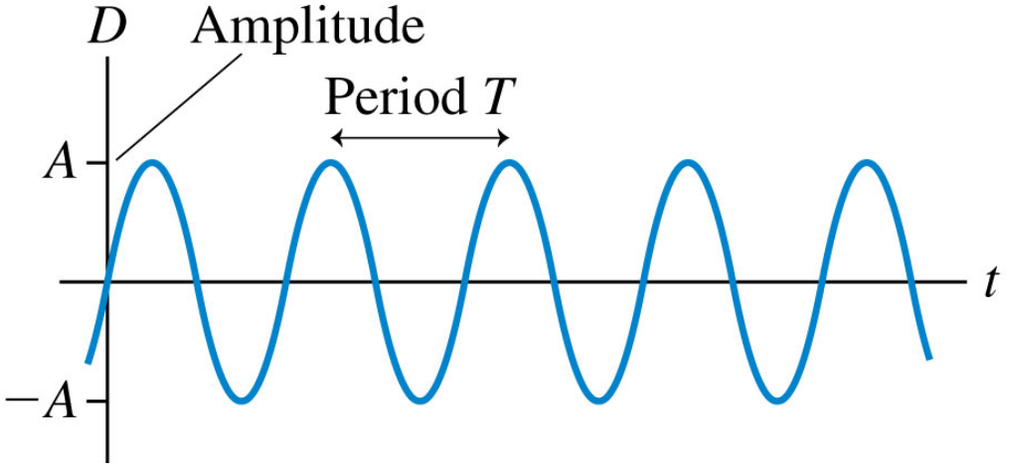
Chapter 20

Traveling Waves

(Sinusoidal Waves & EM Waves)

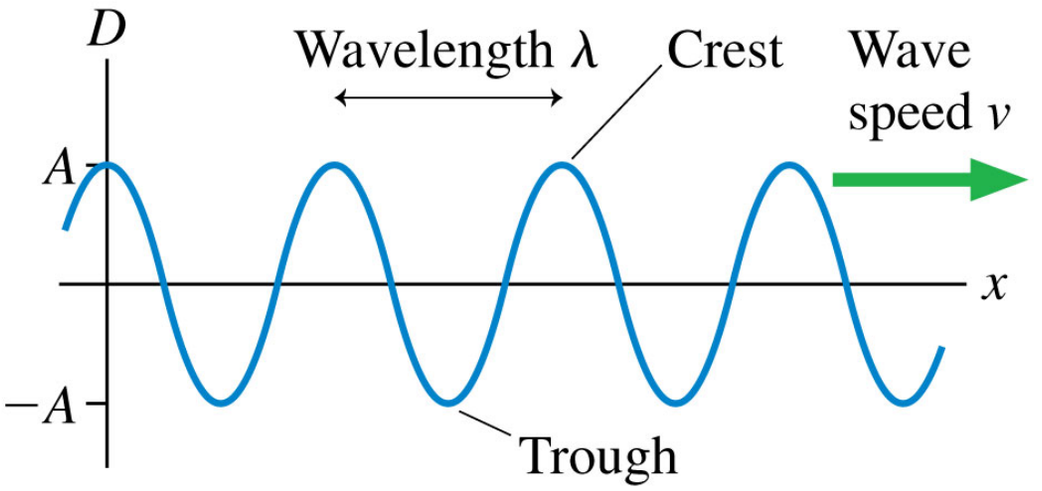
Sinusoidal Waves

- Below is a *history graph* for a *sinusoidal wave*, showing the *displacement of the medium* @ 1 pt in space.
- Each particle in the medium undergoes *simple harmonic motion* with *frequency*, *f*, where $f = 1/T$.
- The *amplitude*, *A*, of the wave is the *maximum value of the displacement*.



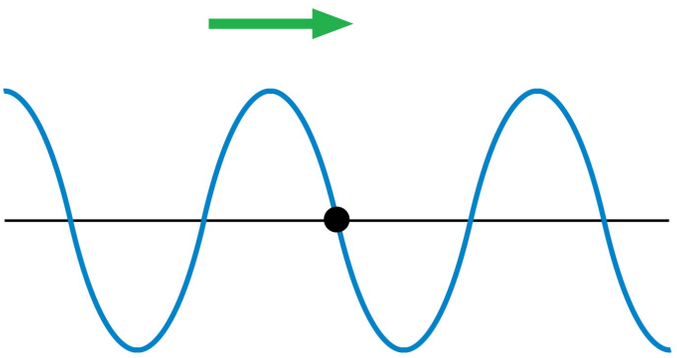
Sinusoidal Waves

- Below is a *snapshot graph* for a sinusoidal wave, showing the wave stretched out in space, moving to the right with speed v.
- The distance spanned by one cycle of the motion is called the *wavelength*, λ, of the wave.



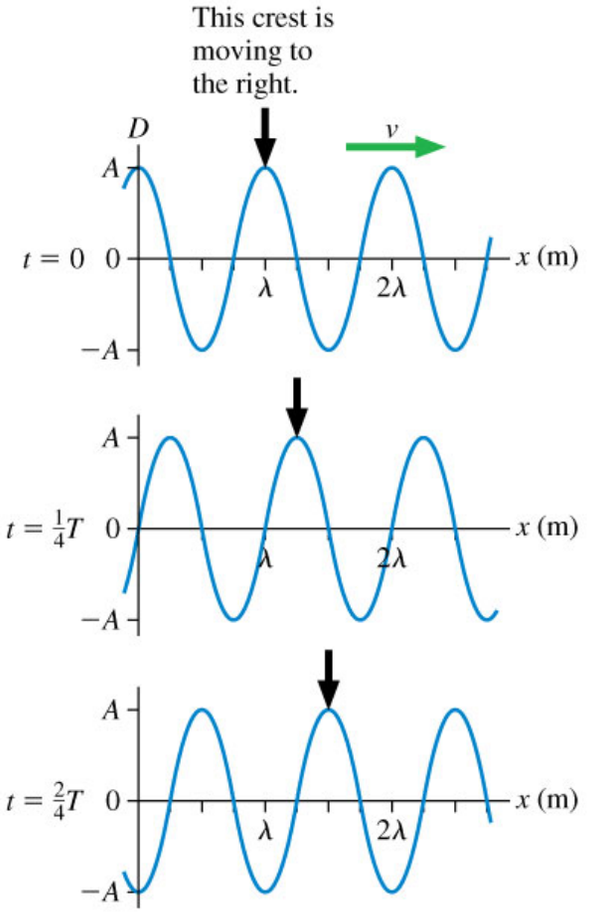
Quiz Question 1

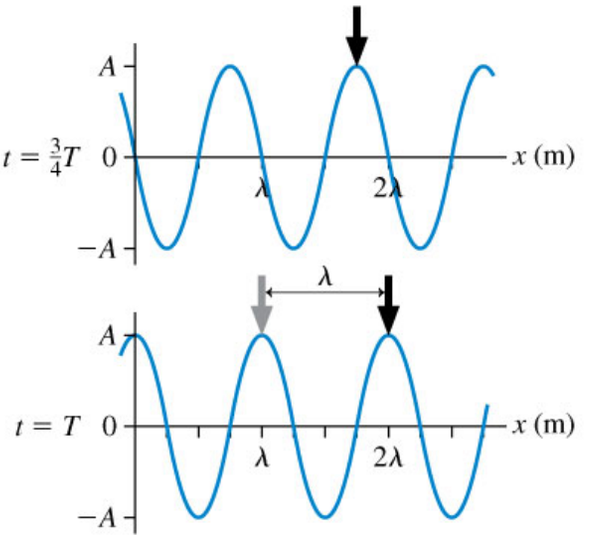
A wave on a string is traveling to the right. At this instant, the motion of the piece of string marked with a dot is



1. up.
2. down.
3. right.
4. left.
5. zero.

Sinusoidal Waves





During a time interval of exactly one period, the crest has moved forward exactly one wavelength.

Sinusoidal Waves

- The distance spanned by one cycle of the motion is called the *wavelength*, λ, of the wave. Notice: $[\lambda] = \text{m}$
- During a time interval of one *period, T*, each crest of a sinusoidal wave travels forward a distance of one *wavelength,* λ.
- The *wave speed* is:

$$v = \frac{\lambda}{T} = \lambda f$$

$$f = \frac{1}{T}$$

Sinusoidal Waves

- The distance spanned by one cycle of the motion is called the *wavelength*, λ, of the wave. Notice: [λ] = m
- During a time interval of one *period, T*, each crest of a sinusoidal wave travels forward a distance of one *wavelength, λ*.
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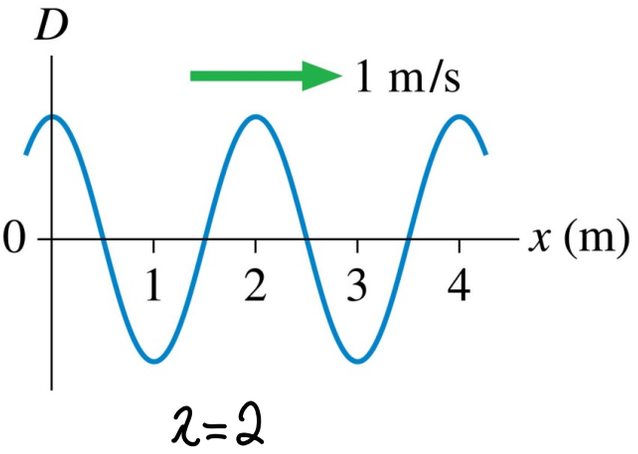
Quiz Question 2

The *period* of this wave is



$v = \frac{\lambda}{t}$

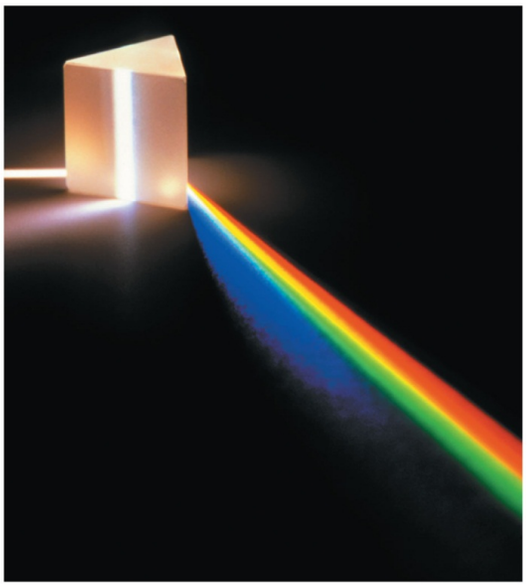
$\frac{v}{\lambda} = f$

$\lambda = 2$

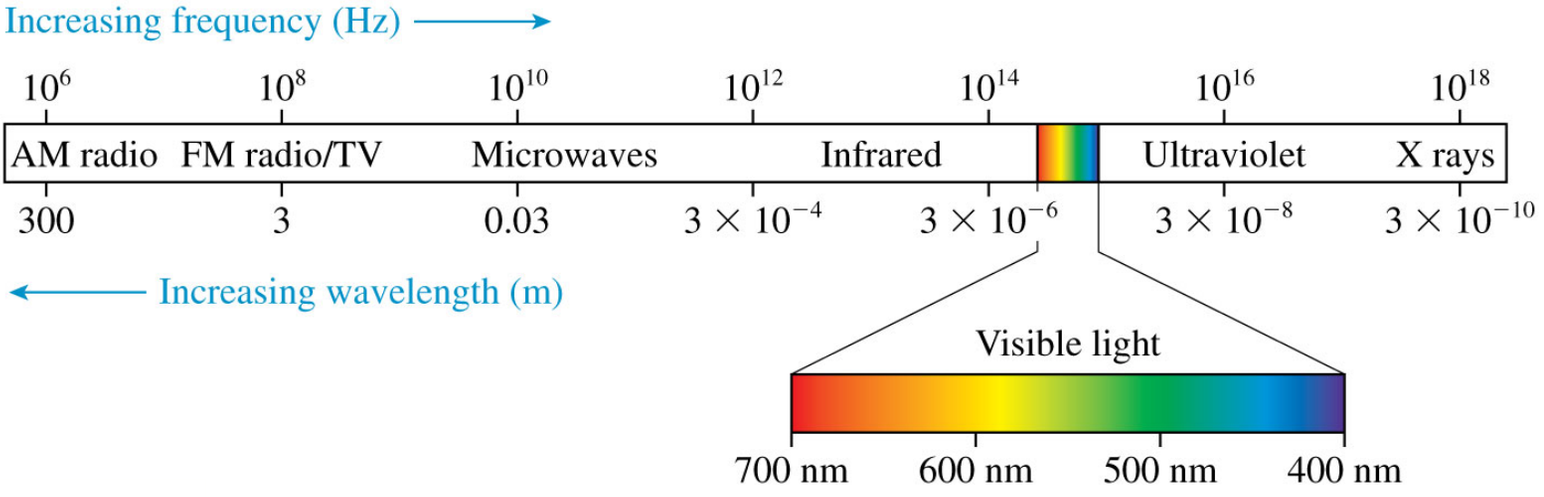
1. ½ s.
2. 1 s.
3. 2 s.
4. 4 s.

Electromagnetic Waves

- A light wave is an *electromagnetic (EM) wave*, an oscillation of the electromagnetic field.
- ALL EM waves have the same physical characteristics as light waves, even though we cannot sense them with our eyes.
- All EM waves travel through vacuum with the same speed, called the *speed of light*.
  - The value of the speed of light is $c = 299{,}792{,}458$ m/s.



Electromagnetic Waves



i.e. 20.7
Traveling at the speed of light

A satellite exploring Jupiter transmits data to the earth as a radio wave with a frequency of 200 MHz.

What is the wavelength of the EM wave, and how long does it take the signal to travel the 800 million kilometers from Jupiter to the earth?

$f = 200 \times 10^6\ Hz$

$d = 800 \times 10^{11}\ m$

$c = 3.00 \times 10^8\ m/s$

$\lambda = \frac{c}{f}$

$\lambda = 1.5m$

$v = \lambda f$

$t = \frac{d}{c}$

$t = 0.75\ hr$

$c = \frac{d}{t}$

$t = 3/4\ hr$

The Index of Refraction

Light waves *slow down* as they pass through transparent materials such as water or glass.

The speed of light in a material is characterized by the material's *index of refraction*, n, defined as....

$$n \equiv \frac{c}{v}$$

TABLE 20.2 Typical indices of refraction

Material	Index of refraction
Vacuum	1 exactly
Air	1.0003
Water	1.33
Glass	1.50
Diamond	2.42

Notice:

$$n \geq 1$$

The Index of Refraction

Q: If the speed of a light wave *slows down* as it enters a material, what happens to the light's *frequency* and *wavelength*?

The Index of Refraction

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A:

- The *frequency of a wave* = the *frequency of the source*. It does NOT change as the wave moves from one medium to another.
- The *wavelength* in the material is…

The Index of Refraction

Q: If the speed of a light wave *slows down* as it enters a material, what happens to the light's *frequency* and *wavelength*?

A:

- The *frequency of a wave* = the *frequency of the source*. It does NOT change as the wave moves from one medium to another.
- The *wavelength* in the material is…

$$\lambda_{mat} = \frac{\lambda_{vac}}{n}$$

Notice:

The wavelength in the material is *less than* the wavelength in the vacuum!